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Diesel Railway Traction

Pulverised Coal Diesels

DESPITE the many obvious difficulties which have to be overcome, it would appear as if considerable progress is being made in the direction of producing a reliable and efficient pulverised-coal-burning diesel engine. Particulars have recently been published in Germany of a number of these engines, including a three-cylinder four-stroke unit developing 150 h.p. at a speed of 215 r.p.m., and a single-cylinder engine developing 140 h.p. at 165 r.p.m. The latter unit, running on brown-coal dust, has been found to consume 7,964 B.Th.U. per h.p.-hr., which corresponds to a thermal efficiency of 32 per cent. Airless injection is employed in conjunction with a pre-combustion chamber, the fuel being fed into this chamber during the suction stroke, the power output of the engine being controlled very satisfactorily by varying the fuel feed. Indicator diagrams show that the combustion pressure depends upon the grade of coal used, reaching a maximum of 795 lb. per sq. in. with hard coal. It is stated that about 99 per cent. of the ash is carried out by the exhaust gases and that the wear caused by the remainder is reduced by tight piston rings and hard-wearing cylinder liners. It is suggested that a large development of engines of this type may be expected in Germany in the near future, but at the moment no experiments have been made with railway diesels.

Horizontal Engines

IN a paper recently read before the Institution of Engineering Inspection, Mr. H. V. Senior advocated the use of horizontal diesel engines for a variety of purposes, including railway traction. The main advantage of this class of engine is that in railcars it increases the revenue-earning space, and its adoption would be looked upon with favour by the operating department as a means of obtaining ninepence for fourpence. It is doubtful, however, whether the position of the engine below the floor would be popular with the maintenance staff. Although trap-doors may be possible at convenient locations, the fact of having to kneel or lie on the floor of the car, or to work underneath in semi-darkness and hampered by brake rods, pipes, and reservoirs, is not conducive to the machine receiving all the inspection which is desirable. Unless the most careful consideration is given to the layout, the power unit will be much more inaccessible than the normal vertical engine mounted on the bogie or underframe, and in many cases even these are not all that can be desired.

Some difficulty may also arise if it is desired to use electric transmission in conjunction with a horizontal engine. Even with high-speed units there is little likelihood of sufficient space being found for a generator below the car floor, and the presence of various essential mechanical portion items in the underframe take a good deal more circumventing than is generally supposed by those who have not had to get right down to the details of design. As the horizontal engine can easily be arranged with two banks of opposed cylinders, the possible range of power is comparatively large, and the system may have some future for locomotive work, more particularly if geared or direct drives make progress. Up to the present the only application has been to a railcar with mechanical transmission, but even in this class of work the advantage of increased passenger accommodation has been obtained in modern designs using a vertical engine and hydraulic torque-converter which are mounted below the underframe without any part projecting through the floor.

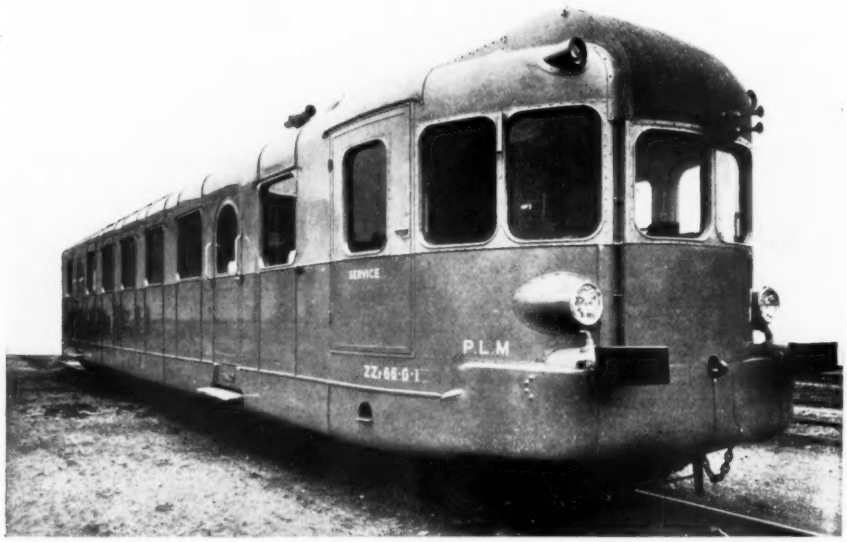
The Scope of Mechanical Transmission

THE *raison d'etre* of all transmission systems in diesel vehicles is to compensate for engine inflexibility, but progress within the last two years has shown this to be but a relative term. The high-speed engines now used in the majority of railcars and loco-tractors have a wide range of economical operation, and experience has proved that their characteristics would be within measurable distance of suiting direct drive if the starting problem could be overcome, as it has been in the partial-hydraulic systems fitted to several modern vehicles. The majority of recent railcars are provided with mechanical transmission, but it is interesting to note that in a range of designs which were prepared to cover approximately the same service, the railcars fitted with two-stroke engines were given a five-speed gearbox in place of the four-speed unit used in conjunction with the more flexible four-stroke engine.

Since the appearance in 1924-5 of the original 75 b.h.p. M.A.N. and 150 b.h.p. Maybach cars of the German State Railway, geared-drive has been applied with fairly consistent success to numerous light railcars up to 150 b.h.p., but there has been a growing tendency within the last eighteen months to incorporate this principle in more powerful vehicles, and in powers up to 350 or 400 b.h.p. it cannot be said that it is deficient in torque-converting properties or that the clutch is unable to stand up to the repeated operations. The main drawback appears to be that simple drives cannot be obtained, because the locations available for the larger engine are strictly limited, and are not necessarily in a favourable position for driving the wheels. A case in point occurs in a well-known Continental railcar of 250 b.h.p., where the torque of the 12-cylinder engine has to be transmitted to a point directly below the sump. The ingenious manner in which this is accomplished is illustrated in another part of this issue, but although the vehicles in question have given exceptionally good service in express and stopping services over a period of twelve months, there cannot be many railway engineers who would not prefer a more direct drive on to the axle. In locomotive work the basic problem rests in the clutch design, for the power and transmission components can usually be laid out in a simple and satisfactory manner, and with the engine designs now available there seems to be no reason why a correctly-designed four-speed gearbox should not provide sufficient flexibility for the most arduous duties. The performance of recent 600 and 1,450 b.h.p. geared locomotives is sufficiently encouraging to justify an expectation that a wide field will be found for mechanical transmission in the higher power range.

A SUCCESSFUL FRENCH RAILCAR

Four-wheeled and double-bogie Renault designs are at work on five of the seven main-line railways of France



250 b.h.p. Renault diesel-mechanical railcar, P.L.M. Railway

ONE of the most striking features of diesel railway traction during the present decade has been the wholesale application of railcars to both light and fast services on the French railways. Nor is there any indication of an abatement in the flood of orders which were a feature of the 1932-33 programmes, and 70 cars of various powers were ordered just before the end of last year, as recorded in the issue of this Supplement for November 3 last.

Among the 200-odd diesel railcars now at work or on order in France, about 60 per cent. have been designed and built by the Soc. Usines Renault. The first vehicles by this firm were ten light four-wheeled diesel-mechanical cars of 85 b.h.p. delivered to the French State Railways in 1930-31. Working mainly on branch services in Normandy and Brittany, this class has now an aggregate mileage of over a million to its credit. Last year the design was slightly modified and enlarged, the b.h.p. being raised to 100, the maximum speed from 56 to 62 m.p.h., and the tare weight from 10 to 11 tons; four cars to this design were introduced on the State lines some months ago.

In 1932 the Renault company turned their attention to the production of a more powerful railcar, and just twelve months ago the first of the now well-known double-bogie 250 b.h.p. vehicles with mechanical transmission was placed on the rails. The initial orders comprised four units for the Etat and two for the P.L.M., the latter forming part of the order for 22 diesel railcars placed by the P.L.M. as a result of an open competition. The immediate success of the design led to its introduction on the P.O., Est, and Alsace-Lorraine Railways, and to

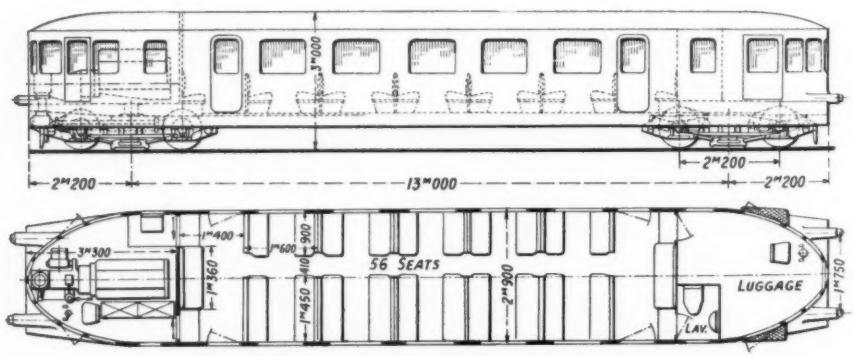


Diagram of Renault standard 250 b.h.p. diesel-mechanical railcar

repeat orders from the other two lines. Although normally arranged for a maximum speed of 78 m.p.h. (*i.e.*, 3½ m.p.h. in excess of the present legal maximum of 74·5 m.p.h.), the design is now being developed for still higher speeds, and six double-articulated cars with a designed maximum of 87 m.p.h. are now under construction for the Etat.

Standard Double-Bogie Car

The 250 b.h.p. double-bogie Renault cars now running on all the big French lines except the Nord and Midi, are all to one design, and vary only in one or two small details according to stipulations of the owning company. Their general appearance is shown by the illustrations of the P.L.M. and Etat vehicles presented with this article, and by the accompanying diagram, which shows the leading dimensions. In the cars now at work, there are 56 third-class seats and room for 10 standing, in addition to lavatory and baggage accommodation, but if required for suburban services the latter could be eliminated and the seating capacity raised to 80. A driving position is arranged at each end, that at the forward end being in the engine room.

Of the two bogies only one is driven, but as the transmission is attached to each axle, the adhesion weight is approximately 17 tons with the car fully loaded. Although extending over a length of 62 ft. 6 in., these vehicles tare scarcely 23 tons, giving an average of 900 lb. per seat, and a b.h.p. of 8·8 per ton against the fully laden weight, with passengers, of 28½ tons. Such proportions not only enable the maximum speed to be easily maintained, but permit of a very rapid acceleration, and the cars geared for a maximum velocity of 78 m.p.h. can attain that speed from rest in 3¼ miles on the level. The construction of the driving bogie is shown in an accompanying illustration, and the trailing bogie is built on similar lines. Standard details include wheels with elastic centres, and S.K.F. roller-bearing axleboxes. Brake blocks on all wheels are applied by compressed-air apparatus, but an electro-magnetic brake operating a shoe on the rail is also fitted to both bogies.

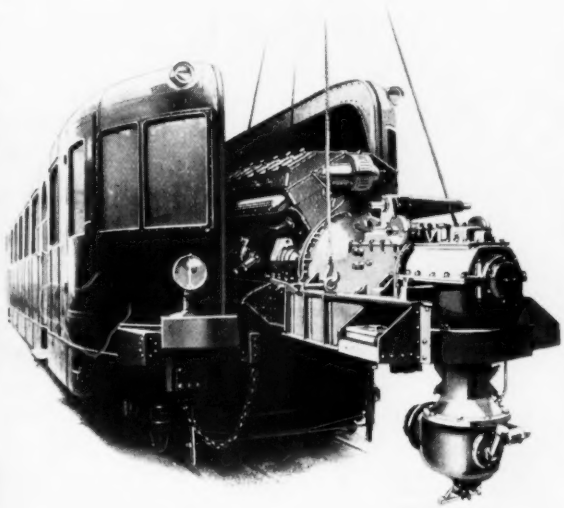
The underframe and body framing are built up of steel as one unit, electric welding being extensively employed in the fabrication. The result is an exceedingly stiff structure which provides a rigid base for the engine and minimises the effect of vibration. The latter is further assisted, as far as the passenger compartment is concerned, by a lining of Cellotex, and light weight is attained by making all the body panels of aluminium. Lighting is carried out electrically from an 850-watt auxiliary generator and a 24-volt battery, and heating is effected by passing the diesel engine exhaust gases down gilled tubes along the sides of the car.

The Engine

Motive power is provided by a 12-cylinder four-stroke V engine evolved by the Renault company specially for rail traction work. The cylinders are 5·12 in. diameter by 6·7 in. stroke, and develop the rated output of 250 b.h.p. at 1,500 r.p.m., giving a brake m.e.p. of 80 lb. per sq. in., and a piston speed of 1,670 ft. per min. The short-time capacity is 310 b.h.p. at the same rotational speed, corresponding to a brake m.e.p. of 99 lb. per sq. in. The cylinder block is cast in one piece of aluminium alloy, and a similar material is used for the pistons, which carry no fewer than five pressure and two scraper rings. Nickel-chrome steel is used for the crankshaft, which is carried on seven bearings, and two connecting rods are borne on each crankpin. There is only one camshaft, driven by a gear train, and 24 cams control the movement of the inlet and exhaust valves.

Airless injection is incorporated and the fuel is injected at a pressure of 3,500 lb. per sq. in. by two six-ram pumps driven through the centrifugal governor, each pump feeding the cylinders down one side of the V. On full load the fuel consumption is 0·44 lb. per b.h.p. hr., and at three-quarter load, 0·46 lb. Cooling of the engine circulating water is effected in a gilled-tube radiator on the roof above the engine room, the water being kept in circulation by a centrifugal pump driven from the engine. When mounted in the car, the engine, clutch, and gearbox from a single unit, and can be lifted in or out complete, as shown in one of the accompanying views, the centre of the engine room roof and end panel being easily removable for this purpose. The engine, clutch, and gearbox unit is given a three-point suspension, being mounted

Interior of Renault railcar



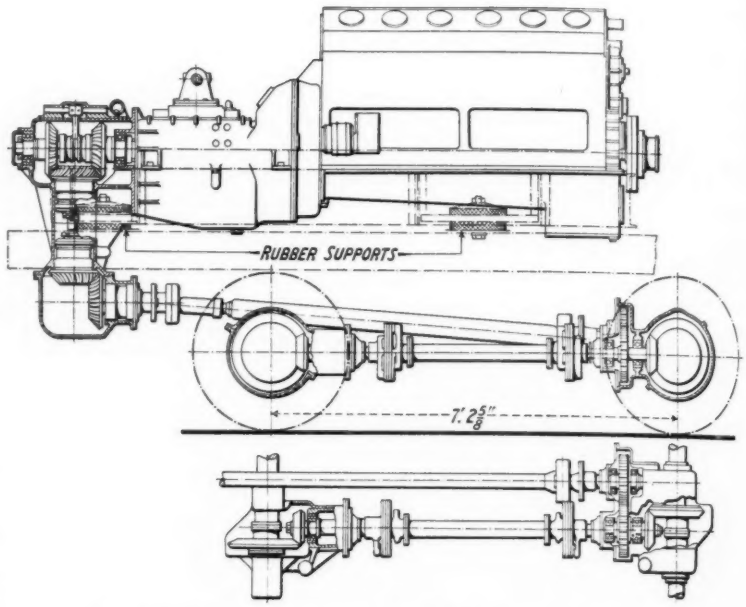
Removing the diesel engine and gearbox

on three double rubber blocks which set on the railcar underframe, and damp out the majority of the engine vibrations.

Transmission

As in every French railcar at the moment of writing, the transmission is mechanical, but the power of the Renault engine is above that of any other design, although, thanks to the high rotational speed, the torque is not excessive. The clutch comprises two steel discs, lined with special material, which are solid with the primary shaft of the gearbox, and act on each side of a central disc forming part of the engine crankshaft assembly.

A four-speed gearbox is fitted on to the end of the engine and clutch casing, and the torque is transmitted from the final shaft through two pairs of bevels to a long cardan shaft which leads to another set of bevels on the inner axle of the driving bogie, the outer axle being driven through the medium of two further sets of bevel gearing, as shown in the arrangement drawing reproduced. In the cars having a maximum speed of 78 m.p.h., the rated revolutions of the engine correspond to a velocity of 74·5 m.p.h., the four gear steps under this condition giving road speeds of 15·7, 28·2, 47·6, and 74·5 m.p.h. The maximum speed is attained in a distance of five km. in five minutes; a speed of 107 km.p.h. in 3·5 km. in four minutes, and 93 km.p.h. in 2·0 km. in 2½ min. The gears are changed by a lever of normal type.



Mechanical transmission of 250 b.h.p. Renault diesel railcar

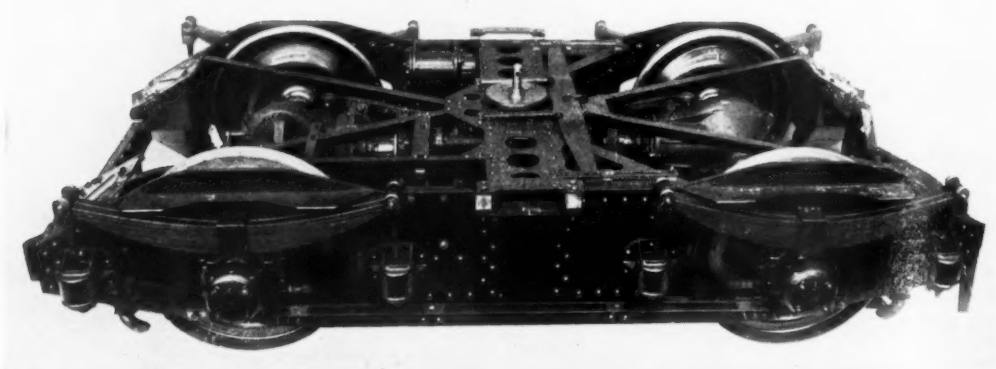
Service Performance

Since their introduction just three years ago, the Renault diesel-mechanical cars, in sizes of 85, 100 and 250 b.h.p., have covered a mileage of over 1,300,000, and now maintain regular services totalling 3,750 miles a day, one car alone making a daily mileage of 366 on fast schedules.

In the course of a number of trials made on the P.L.M. and Etat systems, over a total distance of 1,860 miles at schedule speeds varying from 41 to 68 m.p.h., the 250 b.h.p. cars showed a fuel consumption of 8·6 gal. per 100 miles and a lubricating oil consumption of 0·537 gal. per 100 miles.

On a recent visit to France we travelled in one of the 250 b.h.p. vehicles between Tours and Nantes, a distance of 121 miles, for which 2 hr. 17 min. were allowed inclusive of five stops, giving an overall speed of just over 53 m.p.h. The schedule was easily maintained despite one p.w. check, and the tight intermediate timings between Port Boulet and Saumur, Saumur and Angers, and Angers and Anceries, corresponding to start-to-stop speeds of 58·4, 57·3 and 60·0 m.p.h. over distances of 10·8, 27·2, and 34·2 miles were kept without difficulty, although the legal maximum speed of 74½ m.p.h. was never exceeded.

The 85 and 100 b.h.p. cars have shown an average gross operating cost equivalent to 2·45 fr. per km., and this low figure is in part due to the relatively low initial cost consequent upon an absolutely standard model having been built in numbers. The same applies to the 250 b.h.p. vehicles, whose gross operating cost, assuming maintenance and repairs as 1·05 fr. per km., is approximately 3·95 fr. One hundred of the 250 b.h.p. cars are now on order for various French lines, and the Chemins de fer Economique, the operators of extensive metre-gauge local systems in France, have just put into service two of the 85 b.h.p. vehicles.



Driving bogie of Renault 250-b.h.p. diesel-mechanical railcar

SHUNTING LOCOMOTIVE FOR G.W.R.

Diesel traction experiment in Swindon yard

70 b.h.p. G.W.R. diesel-mechanical shunting locomotive

IN addition to putting into operation the Hardy-A.E.C. passenger railcar, the Great Western Railway last year also acquired a small diesel locomotive for shunting purposes in Swindon works, and although the tractive effort is below that of the normal steam tank engine, it should be quite sufficient for yard service.

As may be seen from the illustration at the head of this article, the wheel arrangement is of the 0-4-0 type, and the layout as a whole corresponds closely to one of the standard designs of the builders, John Fowler & Co. (Leeds) Ltd. The driving wheels, although of only 36 in. diameter, are fitted with full-scale tyres to suit normal rails. They are spread over a base of 5 ft. 6 in., and this restricted length enables curves of 80 ft. radius to be traversed. The superstructure is built up on a normal locomotive frame, and standard buffing and draw gear are fitted. Other fittings include Westinghouse and hand brakes applying blocks on all wheels; hand sanding gear; air-operated whistle, and controls arranged for operation from either side of the driver's cab. The length over buffer beams is 19 ft. 1 in., the total height 10 ft., and the overall width 7 ft. 1 in. The weight of the locomotive in working order is 19½ tons, so that the adhesion factor on the first gear step is 6·25, which is sufficient to ensure complete immunity from slipping.

The oil engine is of the high-speed M.A.N. four-stroke type with direct fuel injection, and develops a rated output of 70 b.h.p. in six cylinders having a bore of 120 mm. and a stroke of 180 mm. The Bosch fuel-injection pump and circulating water pump are driven from the main shaft, and starting is effected through the medium of an auxiliary petrol engine. The quantity of fuel delivered is controlled proportionately to the load on the engine and a totally-enclosed governor is fitted to prevent racing. A Ferodo-lined multiple-plate clutch is incorporated in the engine flywheel, and in view of the loads which are imposed when starting a train, it has been proportioned in excess of the calculated requirements. The clutch and operating mechanism are totally enclosed, and power is transmitted from the clutch through flexible couplings of the internal and external gear type, to provide for any possible stress which may be imposed due to badly laid track. From the rear of this flexible coupling, the torque passes through a totally-enclosed four-speed gearbox, the gears in which are of the constant-mesh type. The final gearbox drive is through a bevel pinion and two bevel wheels; each of the latter are engaged alternately to give forward and reverse movement. From the bevel wheel shaft the drive is transmitted by spur gearing to the jackshaft, the bearings of which are carried directly on the locomotive main frames. Split cranks are attached to the outer ends of the jackshaft, and long connecting rods lead thence to the further wheels. All the principal shafts from the engine to the final drive are carried in ball bearings, and the change-speed gears run in oil. The cast-iron axleboxes are of the normal locomotive type with gun-metal bushes and cast-iron keeps.

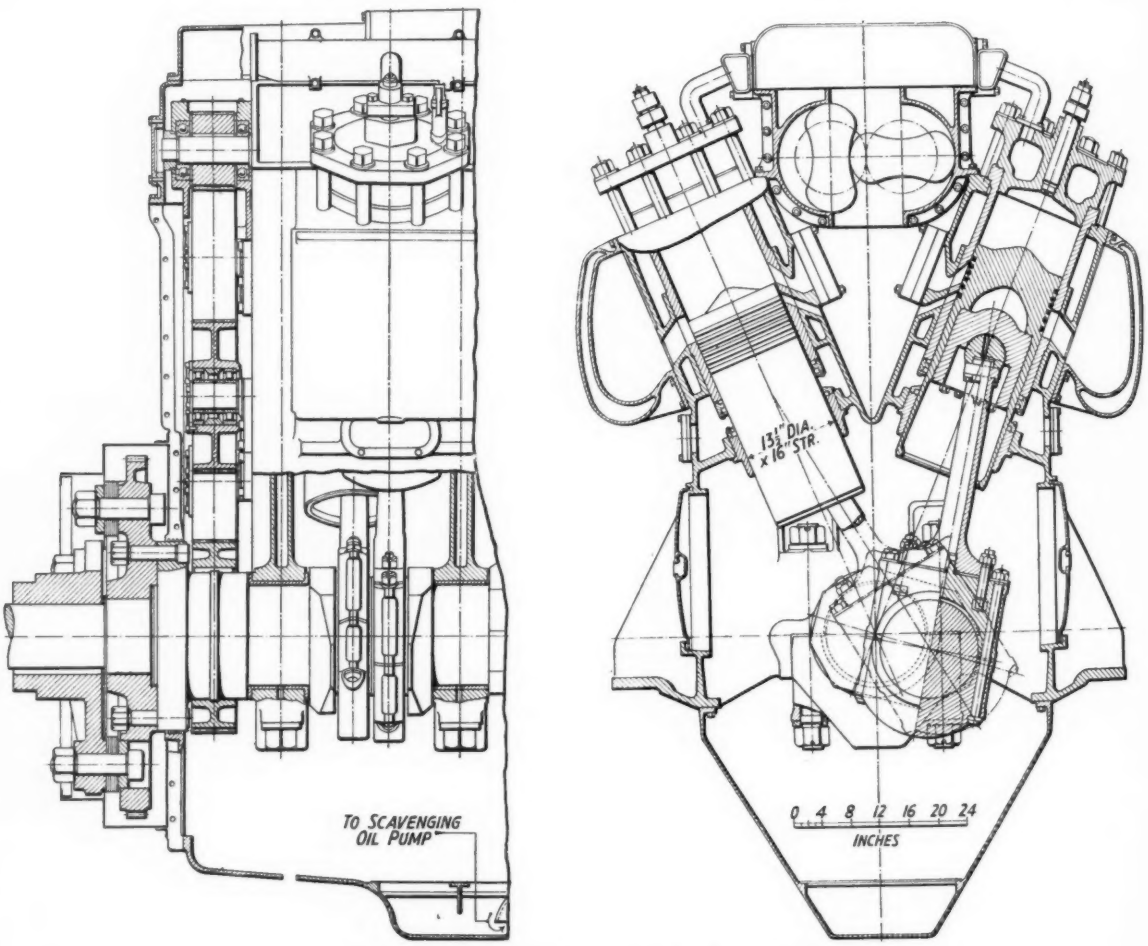
With normal engine revs. the gearbox gives speeds of 3·0, 6·0, 10·2, and 15·0 m.p.h. in each direction, the corresponding tractive efforts being 7,000, 3,500, 2,060, and 1,400 lb. The locomotive has been painted and lined in accordance with Great Western standards, and should prove a handy and efficient addition to the Swindon stock.

BUSCH-SULZER ENGINE

Further particulars of the world's largest locomotive diesel engine

IN our issue of January 26 we described in some detail the 1,600 b.h.p. locomotive diesel engine designed and built by the Busch-Sulzer Bros. Diesel Engine Company, and by the courtesy of that firm we are now able to present sectional drawings of this eight-cylinder two-stroke V-type engine. The cylinders have a bore of 13·5 in. and a stroke of 16·0 in., and the rated output of 200 b.h.p. per cylinder at 550 r.p.m. gives a brake m.e.p. of 63 lb. per sq. in. and a piston speed of 1,465 ft. per min. The weight of the engine is slightly under 25 lb. per b.h.p., and the design provides for the addition of further pairs of cylinders up to a total of 16 cylinders developing a maximum of 3,500 b.h.p. at 600 r.p.m. The largest locomotive diesel engine hitherto in existence in the U.S.A. is the Krupp 1,000 b.h.p. supercharged unit installed in the Baldwin shunting locomotive, and thus it will be seen that a distinct advance has been made in tackling the problem of producing a diesel engine equivalent in power to the normal American steam locomotive.

The first 1,600 b.h.p. engine has now operated well over 500 hr. on the test bed, including a continuous run of 48 hr. at three-quarters to full load. The fuel consumption records of these tests showed that at three-quarter load at half speed the consumption was 0·41 lb. per b.h.p. hour, and at a full load and speed 0·424 lb. per b.h.p. hour.



Longitudinal and cross-sectional elevations of 1,600 *b.h.p. locomotive diesel engine*

The portion of the cylinder block located between the barrels serves as a distributing receiver for the scavenging air, which is furnished by a blower of the rotary positive-displacement type with top suction and bottom discharge. It is driven through gears and a flexible coupling from the engine crankshaft. For those engines exceeding 1,600 b.h.p., *i.e.*, with more than eight cylinders, two blowers are employed, one for each bank of cylinders. Details of the constructional features of the 1,600 b.h.p. engine will be found in the *Diesel Railway Traction Supplement* for January 26.

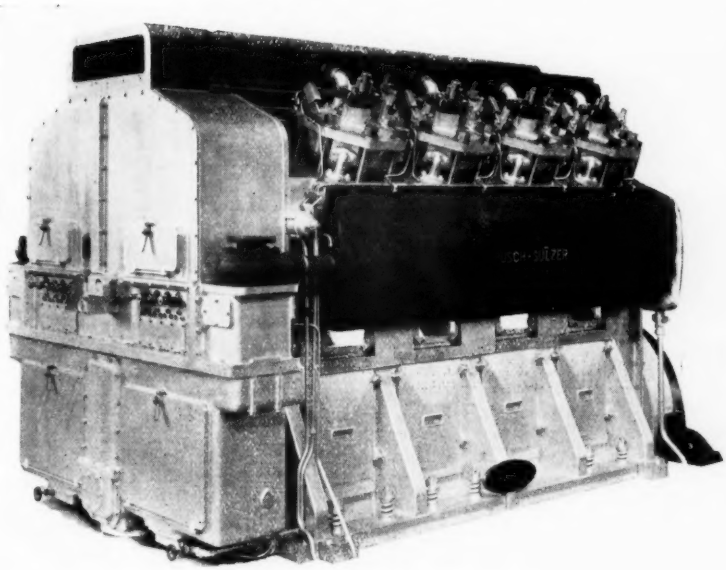
Three locomotive designs embodying this type of engine in different sizes have been got out by the Busch-Sulzer

Bros. company to suit varying American duties. The first is a 102-ton Bo-Bo shunting and short-distance passenger and goods locomotive of 1,600 b.h.p.; the second is a 150-ton 2-Co-2 express passenger locomotive of 2,000 b.h.p.; and the third a 192-ton 2-Do-2 heavy goods locomotive of 3,500 b.h.p. All three types embody electric transmission and force-ventilated nose-suspended motors. The latter are noteworthy in that they will be required to develop 875 h.p. per armature in the heavy freight locomotive, a figure which has so far been unapproached with axle-hung motors.

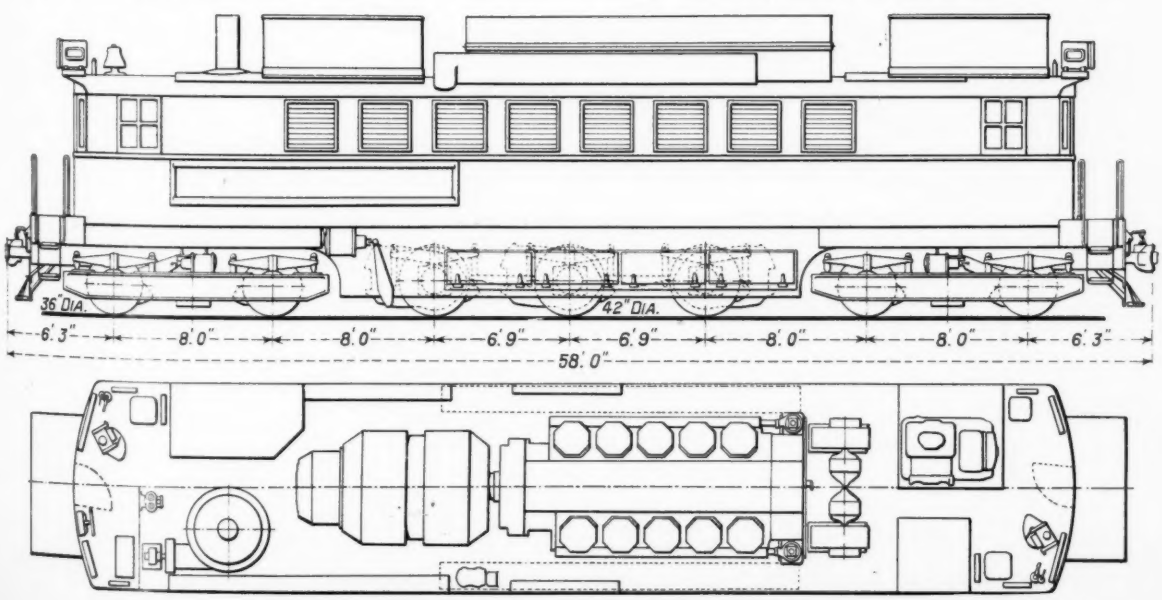
The design for the passenger locomotive is shown in one of the accompanying illustrations. A cast underbed is employed, but frames of the normal type are dropped down to carry the three driving axles. The starting batteries are carried in cases outside the driving axle-boxes, but if it is intended to make the latter of the roller type the inaccessibility of their position is not of great consequence. Two cooling-water radiators are located on the roof and an oil-fired heating boiler is installed. The control is almost entirely automatic, and the transmission is designed to take up the maximum engine power at all road speeds. Starting is effected with all the traction motors in parallel, and a tractive effort of 47,500 lb. can be maintained up to 5·0 m.p.h. At approximately 40 m.p.h., a portion of the traction motor fields is shunted, and this carries the locomotive up to the maximum speed of 75 m.p.h. at which the tractive effort is 7,000 lb. The general capacity is equivalent to the haulage of an 11-car train weighing 775 tons on the level at 60-65 m.p.h. An adhesion weight of 81 tons is estimated, giving a maximum axle load of 27 tons.

The 3,500 h.p. freight locomotive design has an overall length of 62 ft., a rigid wheelbase of 18 ft. 6 in., 48 in. wheels, an adhesion weight of 111·5 tons, and a maximum tractive effort of 75,000 lb., which can be maintained up to a speed of 10 m.p.h. Starting is effected in series-parallel, and changed over to series-parallel with shunted field at 43 m.p.h. The maximum designed speed is 70 m.p.h. The design for shunting and local traffic has an overall length of 43 ft. 6 in., a bogie wheelbase of 7 ft. 9 in., 38 in. wheels, and a maximum tractive effort of 70,000 lb.

Estimates made on the working cost of the 3,500 b.h.p. freight locomotive, with conditions as they now exist in the middle west of the U.S.A., indicate that a saving in working costs of 45 per cent. should be possible compared with an oil-burning steam locomotive of equivalent power. This, however, does not include interest and depreciation charges. The main saving is in fuel, the makers estimating a cost of about 33 per cent. of that of a steam engine.



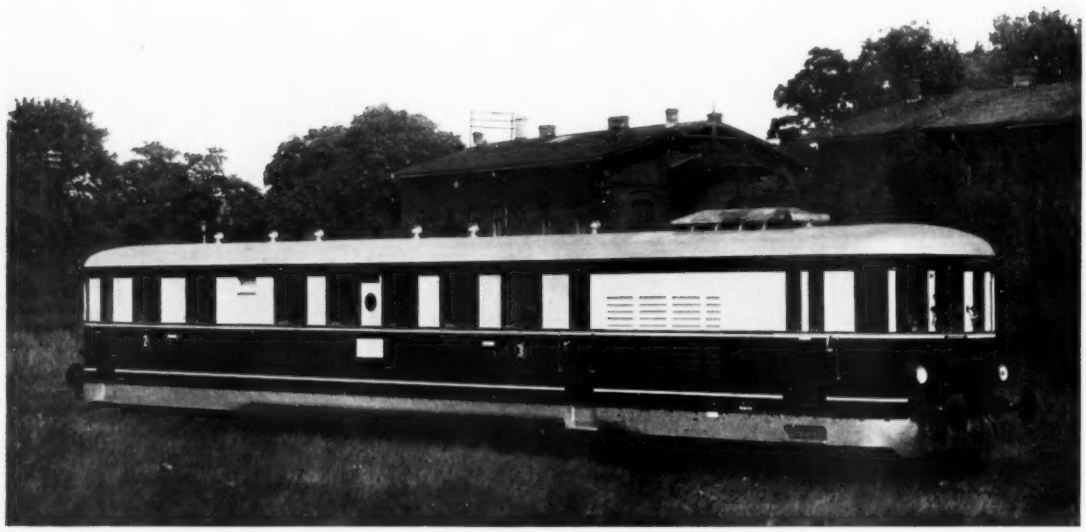
1,600 b.h.p. two-cycle diesel engine



Design for 2,000 b.h.p. passenger locomotive with Busch-Sulzer two-cycle engine

GERMAN RAILCAR WITH TWELVE-CYLINDER ENGINE

New Mercedes-Benz design is now being installed in railcars belonging to the German State Railway

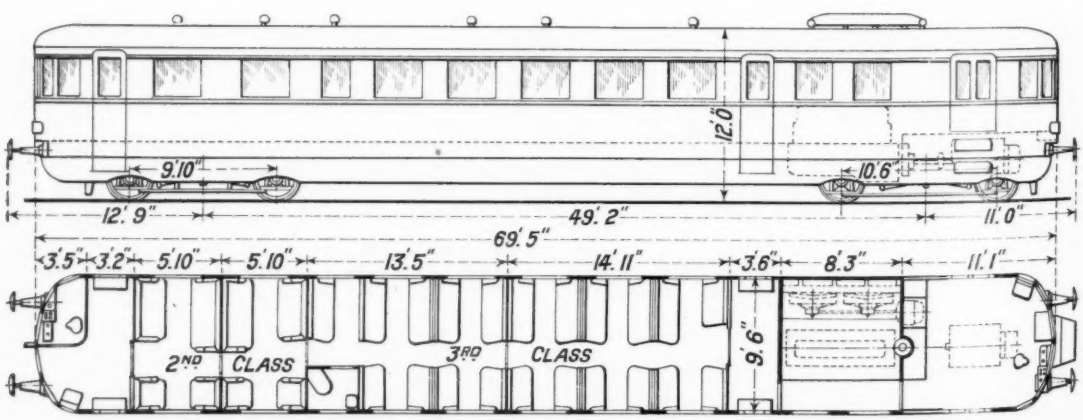


Fast railcar with 12-cylinder engine, German State Railway

FROM the Daimler-Benz works at Stuttgart there has recently emanated a compact and light high-speed diesel engine of the Mercedes type developing 330 b.h.p. at 1,700 r.p.m., the cylinder head and injection arrangements of which are based on those of the six-cylinder 135 b.h.p. engine built by the same firm, as shown in the accompanying cross sectional drawing. These smaller engines have now been running in railcars belonging to the Reichsbahn for over twelve months. The new engine weighs only 4,000 lb., or 12·1 lb. per b.h.p., and has an overall length of 5 ft. 7 in., a breadth of 3 ft. 4 in., and height of 3 ft. 7¼ in.

Twelve cylinders are arranged in two banks of six on a common crankcase made of silumin, and stand on this at an angle of 60 degrees to one another. They are cast in blocks of three with detachable heads, and the inlet and exhaust ports open inwards, that is, into the V of the two banks. The pushrod compartments of the blocks are on the outer sides of the engine, where are situated also the Bosch injection pumps, one for each bank of cylinders.

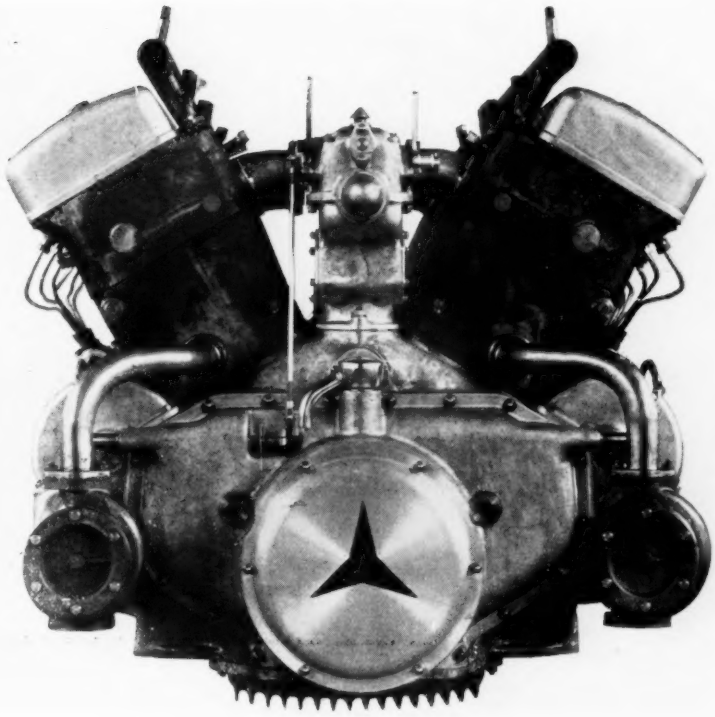
A crankcase of rigid design is provided, and is brought down below the level of the seven main bearings. The attached sump pan is deeply ribbed, and slants downwards towards the flywheel end, where the oil can collect in a recess. The six-throw crankshaft is in one piece, and is balanced as far as is possible without the use of counterweights. Bronze bearing shells lined with lead-zinc are used both for the main and big-end bearings, and to obtain a short engine, master and link rods have been provided,



New Reichsbahn diesel-electric railcar with 330 b.h.p. engine

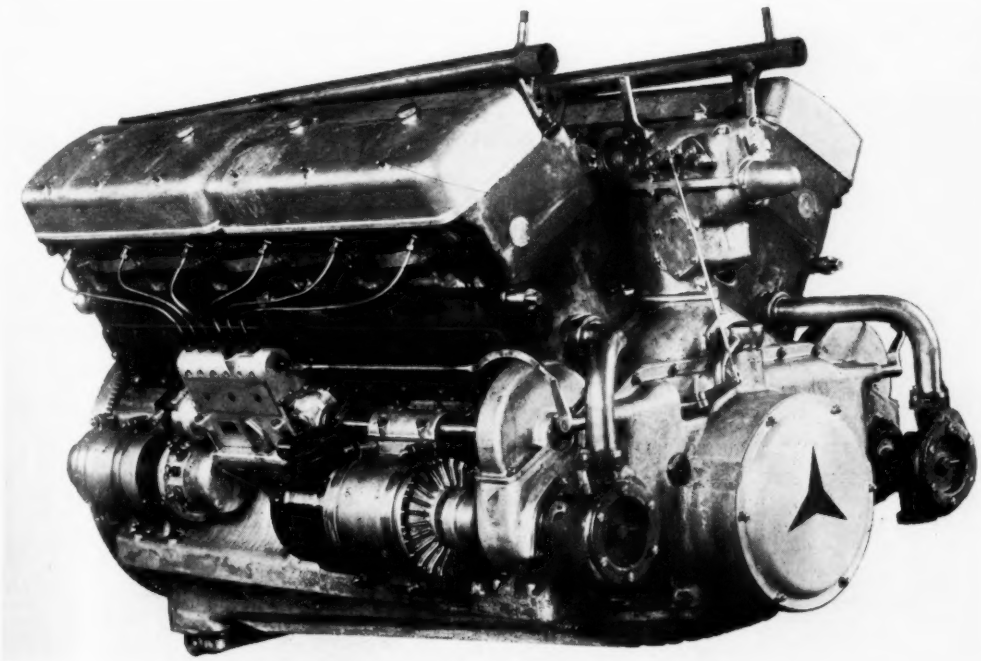
and the lower ends of the latter have Carobronze (phosphor-bronze) bearings on the master rods. The same bearing metal is also used for the connecting rod eyes. Light-alloy pistons with cast-iron ring carriers have been adopted, and the gudgeon pins are fully-floating.

There are two camshafts arranged one in each side of the crankcase, and they are driven from the forward end of the crankshaft by gears. The toothed ring of this gear is cushioned by a number of small coil springs arranged peripherally between it and the star-shaped hub piece. At this end the crankshaft carries a bevel gear driving an upright shaft leading to the governor, which is arranged in a casing between the cylinder blocks, and also a vibration damper, which is enclosed by the timing case cover. The timing case extends beyond the sides of the crankcase and contains on each side two further gears driven off the camshaft gears. The two lower of these gears drive water circulation pumps, one for each bank of cylinders, and the upper gears drive the Bosch injection pumps. The right water-pump gear also drives a 1,200-watt 24-volt dynamo clamped on the crankcase.

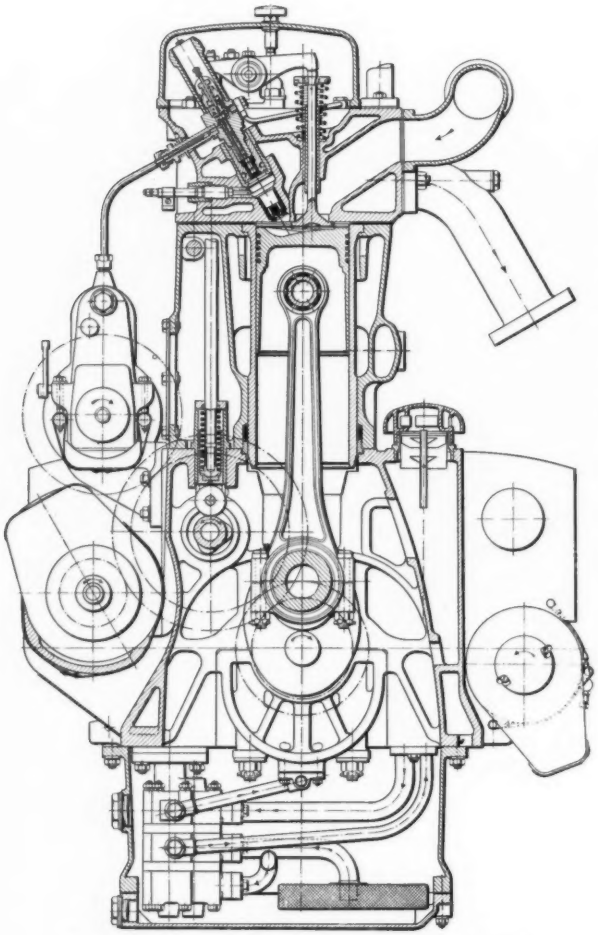


End view of 330 *b.h.p. Mercedes-Benz engine*

The cylinder blocks have wet liners of chrome-nickel cast iron, with a bore of 138 mm. (5·43 in.) and a stroke of 170 mm. (6·69 in.), giving a total piston displacement of 30·5 litres. Mercedes-Benz pre-combustion chambers are inserted in the detachable cylinder heads, in which the Mercedes patent atomiser is screwed. The pre-combustion chambers are inclined at about 35 degrees to the cylinder axes, and stand near the outer edges of the cylinder heads between the two valves, which are arranged standing all in one line slightly inwards from the centre line of the cylinder bank. The valves are operated in



Mercedes-Benz 12*-cylinder* 330 *b.h.p. railcar diesel-engine*



Cross-section of 135 b.h.p. Mercedes-Benz engine as used in German railcars

the usual manner by pushrods and rockers. The latter are mounted on hollow shafts, which are supported by four brackets on each cylinder head. The whole valve mechanism on the cylinder heads is enclosed by light metal covers which leave a ledge on the inner side of the heads, where the water outlet pipes are fitted.

Dry sump lubrication has been adopted. A dual geared pump in the sump recess is driven by means of skew gear off the right camshaft, and the lower pump delivers the oil collecting around it to an external tank, into which it flows through a strainer. The upper pump draws the oil from the tank and delivers one part of it to the main bearings, and the remainder to the hollow camshafts and the hollow shafts carrying the valve rockers. From the main bearings the oil reaches the big ends, whence it passes up tubes fitted on the flanks of the master rods and up the hollow link rods to the gudgeon pins. A secondary oil line branches off the main distribution system to an external filter mounted on the left side of the crankcase at the forward end.

The flywheel of the engine is provided with teeth, which can engage with the pinions of two 12 h.p. electric starting motors fitted one on each side of the crankcase. To facilitate starting, heating plugs are fitted in the precombustion chambers at right angles to the injection nozzles, which are co-axial with the chambers. To free the bearings before starting, the exhaust valves can be decompressed by means of short pushrods standing on flat faces on shafts passing through the pushrod compartments of each cylinder bank. The governor is mounted on a horizontal shaft and controls idling and maximum speed, which latter can be regulated at the discretion of the driver, *i.e.*, the governor will prevent the engine exceeding any speed that is desired. The forward end of the governor shaft can be provided with a slip clutch and fan if it is possible to mount the radiator immediately in front of the engine. The governor controls the fuel charges of both injection pumps through a transverse shaft passing through the timing gear case, with which it is connected by levers and a rod. The projecting ends of the transverse shaft carry levers, which are connected by rods with the plunger control racks in the pumps.

As such engines cannot usually be kept under the immediate observation of the drivers, electrical control instruments are provided on this Mercedes-Benz engine. Behind one of the injection pumps an electrical revolution counter is fitted, the current of which can be conducted to two or more dials conveniently distributed over the railcar. There are similar electrical thermometers and oil pressure gauges.

During tests conducted by the Reichsbahn the performance of the engine was so satisfactory, that the railway authorities ordered a number of them without awaiting the results of practical service. In the table given below the readings given under A are for the engine fitted with 1,200-watt dynamo running idle, with suction and exhaust manifolds, the latter water-cooled, but without silencer and without fan. The B readings give the performance with dynamo, silencer and fan running.

R.P.M.	B.H.P.		B.M.E.P. (lb. per sq. in.)			
	A.	B.	¼ Load	½ Load	¾ Load	Full Load
700	154	146	22·7	48·3	69·7	91·0
1,000	232	220	25·6	51·2	72·5	96·7
1,300	300	280	25·6	49·8	72·5	96·7
1,500	336	310	24·2	47·0	70·0	93·8
1,700	358	326	22·7	44·0	68·3	89·6

The engine develops its highest torque between 900 and 1,300 r.p.m., when it attains from 1,157 to 1,171 ft.-lb. At 700 r.p.m. the torque is 1,099 ft.-lb., at 1,500 r.p.m. 1,114 ft.-lb., and at 1,700 r.p.m. 1,042 ft.-lb. Fuel consumption is lowest at 1,000 r.p.m. when 0·425 lb. is used per b.h.p. hr. ; at 1,300 r.p.m. it rises to 0·429 lb., at 1,500 r.p.m. to 0·44 lb., and at 1,700 r.p.m. to 0·48 lb. per b.h.p. hr. The lubricating oil consumption averages 0·018 lb. per b.h.p. hr.

These engines are mounted in all-steel double bogie railcars weighing 50 tons, and seating 14 second-class and 52 third-class passengers in an overall length of 72 ft. 11 in. The engine, and its attached 200 kW. A.E.G. generator, are mounted directly on a bogie having a wheelbase of 10 ft. 6 in., and the two 106 kW. traction motors drive the 35½ in. wheels of the remaining bogie, which has a wheelbase of 9 ft. 10 in. Roller bearing boxes are employed for all axles, and welding has been largely used in the construction of the body and underframe. The cars, which are shown in the illustration at the head of this article, and in the accompanying diagram, are virtually duplicate with those powered by 410 b.h.p. Maybach and 300 b.h.p. Motorenwerke Mannheim engines, which were described in the issues of the *Diesel Railway Traction Supplement* for July 14 and October 6, 1933. Most of the cars, including that illustrated herewith, have been built by the Triebwagenbau A.G., of Berlin, and are fitted with Gebus electrical control.

L.M.S.R. RAILCAR TRIAL

Third Leyland vehicle puts up good performance on main line

The second of the Leyland cars between Blackpool and St. Anne's

ON Sunday last an extremely interesting trial run took place between Preston and Carlisle with the last of the three diesel hydro-mechanical railcars designed and built for the L.M.S.R. by Leyland Motors Limited to the requirements of Mr. W. A. Stanier, the railway company's Chief Mechanical Engineer.

The car in question differs from its two forerunners only in having a somewhat lower gear ratio on the driving axle, by means of which the maximum road speed, with the engine governed at 2,000 r.p.m., is raised to 63 m.p.h. compared with 56 m.p.h. of the first two cars. The 90·1 miles from Preston to Carlisle were covered non-stop in 115 min. 15 sec. at an average of 47 m.p.h., but being well ahead of schedule at Shap summit, the car was run under "easy steam" thence to Carlisle, the speed at no point of the descent exceeding 56 m.p.h., that is, only a couple of miles an hour more than the average speed up the four miles of 1 in 75 on the southern side, over which the speed varied only between 54 and 56·2 m.p.h. The 5·5 miles from Tebay to Shap Summit box were covered in 6 min. 4 sec., an average of 53·7 m.p.h., despite a heavy snowstorm which first caught the car between Low Gill and Tebay.

A booked speed of 44 m.p.h. was allowed in the railway company's special timetable, but, despite dawdling from Shap and easy running before Carnforth, the time was cut by eight minutes. Booked and actual times are shown in the following table, but it is worth noting that at no point on the outward journey did the speed exceed 59 m.p.h.

	Booked	Actual
Preston .....dep.	8.20	8.17.55
Oxheys .....pass	8.23	8.20.56
Garstang..... ,,	8.33	8.29.58
Lancaster ..... ,,	8.47	8.44.30
Carnforth ..... ,,	8.56	8.54.05
Oxenholme..... ,,	9.13	9.09.40
Tebay ..... ,,	9.33	9.24.58
Shap Summit..... ,,	9.45	9.31.02
Penrith ..... ,,	10.00	9.48.25
Plumpton ..... ,,	10.06	9.56.25
Carlisle .....arr.	10.23	10.13.10

There were between 25 and 30 persons on board, raising the tare weight of 10½ tons to approximately 12½ tons. The fuel consumption for the 90-mile trip averaged just over 13½ m.p.g.

On the return journey, Carlisle was left at 11.9 a.m. and Preston reached at 1.20 p.m., but no effort was made to achieve anything spectacular, and five stops were made in addition to carrying out brief track-circuit tests between Galgate and Bay Horse. Track-circuit testing of a more comprehensive nature was carried out with the car in the afternoon between the same two stations. A maximum speed of 61 m.p.h. was attained on the return journey. Several of the party had the privilege of driving the car between Carlisle and Lancaster, and found it very simple and easy to handle. The controls are all arranged on one dashboard, and actual driving operations are limited to three details, viz., the throttle, change-over switch for the transmission, and the vacuum brake. On the occasion of last Sunday's trip, however, the most-used instrument on the dashboard was the hooter button!

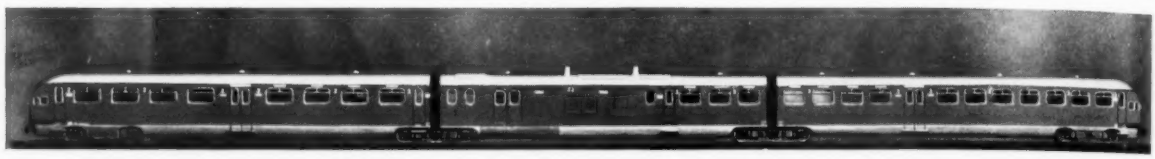
Some interesting acceleration figures were obtained on various level stretches of the line, and these are given below. They do not refer to the maximum possible rate, but are typical of what can be done in normal operation without any special effort on the part of the driver.

	No. 1	No. 2	No. 3
¼ mile..... sec.	35⅘	37	32
½ mile..... ,,	60	60	55
¾ mile..... ,,	80	81	76
1 mile..... ,,	97	98	96

Among those present at the trials were Messrs. T. H. Hornbuckle, L.M.S.R.; O. Bulleid, L.N.E.R.; A. A. Liardet, General Manager, and Dr. H. F. Howarth, Research Engineer, Leyland Motors Limited; General Pack, late Director of Mechanical Transport, War Department; MM. Leguille and Dumas, of the Ch. de fer de l'Est and the Ch. de fer du Nord respectively, and Mr. A. L. Fielding, of the New South Wales Government Engineer's Department.

DUTCH DIESEL TRAINS

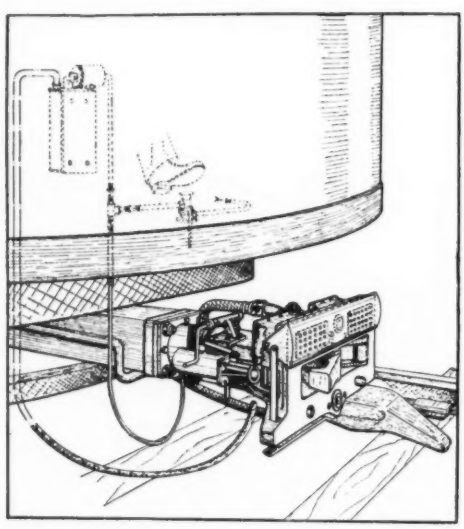
Operation of an important line by streamlined articulated units is to begin in May



820 *b.h.p. diesel-electric trains, Netherlands Railways*

ON May 15 next, an important era in the history of the Netherlands Railways will begin with the inauguration of a regular service of diesel-electric trains on the Amsterdam-Utrecht-Arnheim; Rotterdam-Utrecht; Utrecht-Eindhoven; and Utrecht-Hague divisions, which have a total route mileage of 175. It is intended that eventually all trains except international expresses over the above sections will be operated by the 40 diesel trains on order, but it is anticipated that only 16 trains will be ready for service when the summer time-tables come into force in May, and these will go into traffic on the Amsterdam-Utrecht-Arnheim line.

As recorded in the issue of this Supplement for April 21, 1933, these 40 trains are triple-articulated units, 35 of them being powered by two Maybach 410 b.h.p. engines and the remaining five by two Ganz-Jendrassik 375 b.h.p. engines. Actually, 80 Maybach engines are being delivered, and ten will be held in reserve as spares. As much work as possible in connection with the complete order has been given to Dutch firms. The Werkspoor N.V., of Amsterdam, has received the biggest share, for the mechanical portions of 25 train sets, and 20 Maybach engines, the latter being built under licence. The other 60 Maybach engines are being constructed at Friedrichshafen. J. J. Beijnes N.V., of Haarlem, is building ten train sets, and the remaining five are under construction at the Allan works in Rotterdam. The 375 b.h.p. Ganz-Jendrassik engines are being built under licence by Stork Bros., of Hengelo. So far as the electrical equipment is concerned, 35 sets are being constructed to the designs and specification of Brown-Boveri, two-thirds of the material being built under licence by the Heemag N.V., and the remaining third in the Baden and Munchenstein shops of Brown-Boveri. The last five sets of electric transmission are being supplied by the Smit works, of Slikkerveer, to Westinghouse designs, and will be fitted to the Ganz-engined cars.



Special type of multi-purpose coupling used on diesel trains, Netherlands Railways

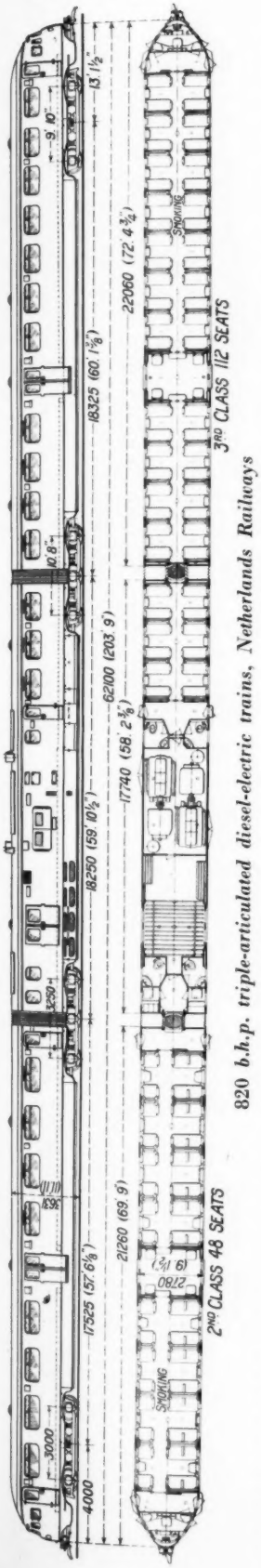
Streamlined Contour

From the general arrangement drawing presented with this article, it will be seen that these triple-articulated trains are streamlined in a similar manner to the Flying Hamburger; the contour of both types was determined as a result of wind-tunnel experiments carried out at the Zeppelin works, Freidrichshafen. The main difference compared with the Flying Hamburger is that an extra coach body has been introduced to carry the two power sets, which are located side by side in the centre car. The end bogies are simply carrying units, and the six-wheeled articulation bogies each carry two nose-suspended electric traction motors.

The tare weight of the complete three-car train is approximately 80 tons, giving a ratio of two passengers per ton, a value which is to some extent affected by the two classes of accommodation provided. The 10 b.h.p. per ton of tare weight will permit of rapid acceleration up to 62 m.p.h., this being the maximum speed at which it is intended to run in normal service. The maximum designed speed, however, is 87 m.p.h. Seating accommodation for 48 second-class and 112 third-class passengers is provided, and is arranged as shown in the accompanying diagram. Luggage room and lavatories are incorporated in the centre vehicle.

With a view to saving weight, the carriage bodies are being fabricated by the electric welding of light sections and tubes, and the truck frames are also completely welded up. This practice is an extension of that applied to main-line coaches of the Netherlands Railways, as described in THE RAILWAY GAZETTE for April 21, 1933. Light axles and wheels of the Uerdingen type are used, and the axles run in roller bearings. Light-metals have been largely used in the construction of the doors, parcel racks, heating conduits, fuel tanks, and other fittings. The second-class seats are fitted with springs and upholstered in plush, and the third-class seats are of the expanded-rubber type with artificial leather upholstery.

In the engine room are two power plants, each consisting of a diesel engine directly coupled to a d.c. generator which applies current to two traction motors. A driving cabin is provided at each end of the train, and the fittings in each are duplicate. Auxiliaries such as the air-brake compressor motor and traction motor blowers are supplied with current from an auxiliary generator, which also serves to excite the fields of the main generator and charge the



820 *b.h.p. triple-articulated diesel-electric trains, Netherlands Railways*

storage battery. Starting of the engine and lighting of the train are effected electrically, current being supplied from the battery, which is located beneath the underframe of the centre car.

Particular attention has been paid to the heating and ventilating arrangements of these trains. The temperature in the carriages is regulated by thermostats, and heating is normally effected by circulating through the interior air which has been heated by the engine cooling water in a special heater. In very cold weather this is supplemented by hot water from an automatically-controlled oil-fired steam boiler, the burner of which is switched on or off through the action of the thermostats. In summer the same quantity of air is circulated, but the cooling water is by-passed from the air-heater. In the five Ganz - engined trains the silencer is water-cooled.

Knorr - Lambertsen air brakes are used, and the equipment permits of graduated application and release. It is claimed that even with a full application at the highest speeds, the action is smooth and free from shock. The normal type of railway brake has been given up in favour of the drum pattern. Each road wheel has a drum with two shoes, and a brake cylinder for each shoe is mounted on the bogie frame. All the brake cylinders on one bogie are served by a single triple valve and auxiliary reservoir.

Multiple - unit control is embodied, and in order to couple or uncouple two trains in the shortest possible time automatic couplers of the Universal-Scharfenberg Unirop type are fitted. By a simple running together of the vehicles, this device at one and the same moment enables the coupling of the drawbars, air-brake conduits, and electrical connections. Release is effected by depressing a foot pedal in the driving compartment, and this action first puts out the mechanical coupling, then closes the air-brake line in the ends of the two units, and then a pull-switch disconnects the electric jumpers. As soon as the pedal is released, both units are ready to move off in their respective directions.

Frichs Oil Engines

Two new catalogues have recently been issued by A/S Frichs, of Aarhus, containing the illustrations of that firm's products, brought up to date, which were previously published with descriptive matter in a single set of covers. The first, entitled "Diesel Locomotives and Railcars," contains, in addition to illustrations of the well-known Frichs diesel-electric locomotives and railcars of the Danish State and Siamese State Railways to which we have referred so often in these pages, a view of the new 480 b.h.p. express railcars now being put into traffic on various sections of line in Denmark and which are dealt with on another page of this issue. Loco-tractors of 60 to 90 b.h.p. are also shown, as is the diesel-mechanical car with a Humfrey-Sandberg free-wheel, which was fully described in the *Diesel Railway Traction Supplement* for July 14, 1933.

The second brochure bears the title "Diesel Engines for Locomotives and Railcars," and the illustrations contained therein are of special interest, as they represent the new range of Frichs engines, which for locomotive purposes are built in powers of 178 to 1,570 b.h.p., and for railcar work from 60 to 480 b.h.p. The larger sizes of locomotive engines can be fitted with superchargers, which raise the outputs from 27 to 29 per cent.

FRICHS DIESEL ENGINES FOR LOCOMOTIVES

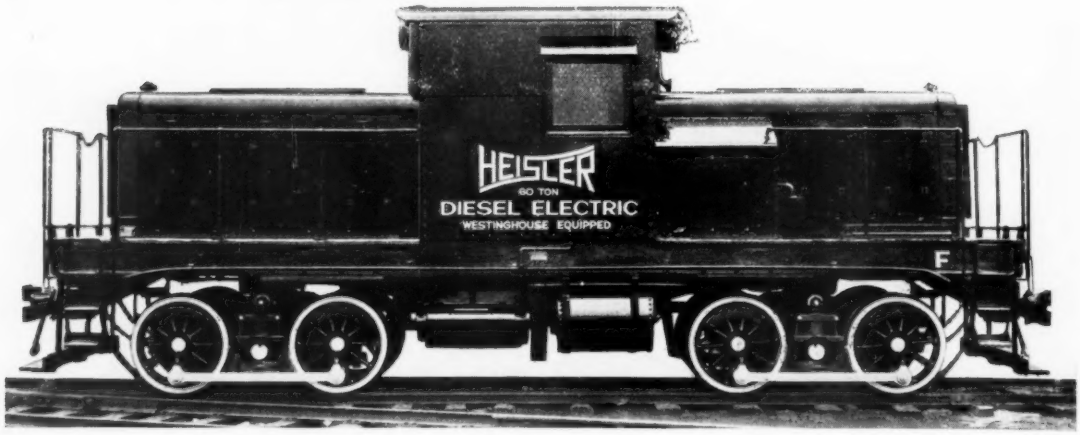
Cyls.	R.P.M.	B.H.P.		B.H.P. with super-charging	Weight in lb.	
		Normal	Max.		Without super-charging	With super-charging
6	875	178	195	—	5,300	—
6	800	220	240	—	6,600	—
6	750	275	300	—	8,600	—
6	700	330	360	—	10,600	—
6	650	415	455	—	14,400	—
6	650	500	550	—	17,300	—
6	650	590	650	—	21,000	—
6	615	685	750	—	25,400	—
6	580	840	920	—	32,000	—
8	650	550	600	770	18,700	20,000
8	650	665	730	930	23,200	24,700
8	650	785	860	1,100	29,500	31,300
8	615	915	1,000	1,280	34,500	36,400
8	580	1,120	1,220	1,570	43,500	46,000

FRICHS LIGHT-WEIGHT DIESEL ENGINES FOR RAILCARS AND TRACTORS

Cyls.	R.P.M.	B.H.P.		Weight in lb.
		Normal	Max.	
6	1,800	60	65	915
6	1,400	82	90	1,325
6	1,200	115	125	1,960
6	1,100	150	165	2,960
6	1,000	220	240	3,800
12	1,400	365	400	5,000
12	1,000	400	480	6,100

A NOVEL DIESEL LOCOMOTIVE

Worm drive and coupling rods incorporated in double-bogie machine



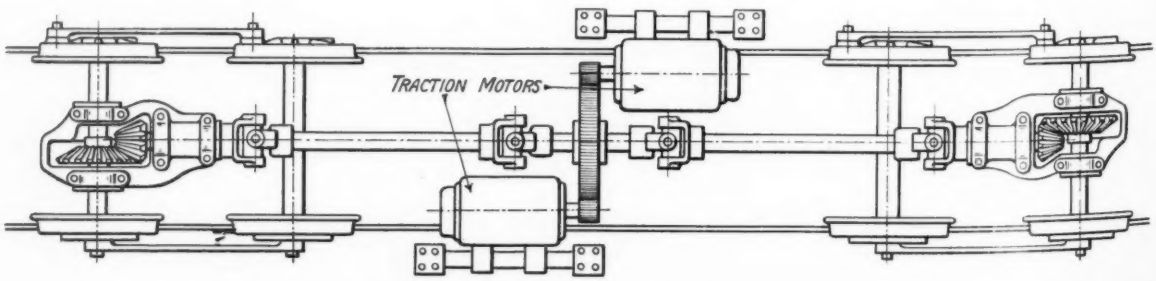
360 b.h.p. diesel-electric locomotive for heavy shunting service

AN oil-electric shunting locomotive, the design of which embodies the results of long experience with geared steam locomotives, has recently been developed by the Heisler Locomotive Company, of Erie, U.S.A. Although of the double-bogie type, the layout does not incorporate the usual four nose-suspended traction motors, but two high-speed motors are mounted beneath the underframe, each of which drives one axle of each bogie through a cardan shaft and bevels.

Both armature spindles are connected to a central driving shaft through simple spur and pinion gears. Each end of this centre shaft is connected through a Hooke joint to a long cardan shaft, which transmits the torque to a pair of bevels mounted on the outer axle of each bogie, the four wheels of the bogie being coupled by rods. The whole weight of the locomotive is thus available for adhesion, and owing to the high gear ratio which this simple method of drive permits, a tractive effort up to the slipping point of the wheels is obtained from only two motors, which are comparatively small and light. On test, a factor of adhesion of under three has been obtained.

In the locomotive illustrated, each traction motor is of 230 horse-power, with a maximum speed of 1,830 r.p.m., and as the power plant consists of two entirely separate diesel engines with attached generators, each motor is supplied with current from its own set, and, when circumstances warrant, the locomotive can be operated with only one power set in use, the diesel engine thus being worked at high efficiency. Each prime-mover is a six-cylinder Buda-M.A.N. engine developing 180 b.h.p. at 1,000 r.p.m., with a fuel consumption of 0·4 to 0·45 lb. per b.h.p. hour. Starting is effected electrically, current being supplied to the main generator from a 272 amp.-hr. Exide battery. The bonnets at each end of the locomotive contain the power sets, and radiators are mounted on the ends. Fans are not used, portions of the air passage through the radiator being blocked off by closing shutters when the engine is not working at full capacity. 160 U.S. gallons of fuel are carried, this capacity being sufficient for 24 hours of normal service. Fuel is injected into the cylinders by a pump with a fixed length of stroke, the amount of fuel injected being automatically controlled by mechanically-operated by-pass valves in the line from pump to cylinders. The lubrication is on the high-pressure system, the pressure being regulated by a spring-controlled valve set to a normal pressure of 30-40 lb. per sq. in.

A combination engine-throttle and electro-pneumatic control is embodied, and includes a remote type of series-parallel controller having a reverse handle, and a speed handle which controls the electro-pneumatic switches, magnetic contactors, and engine throttle. The control equipment also includes edge-wound generator field resistances; knife switch for battery cut-out; meter indication of generator load and battery charge; automatic control



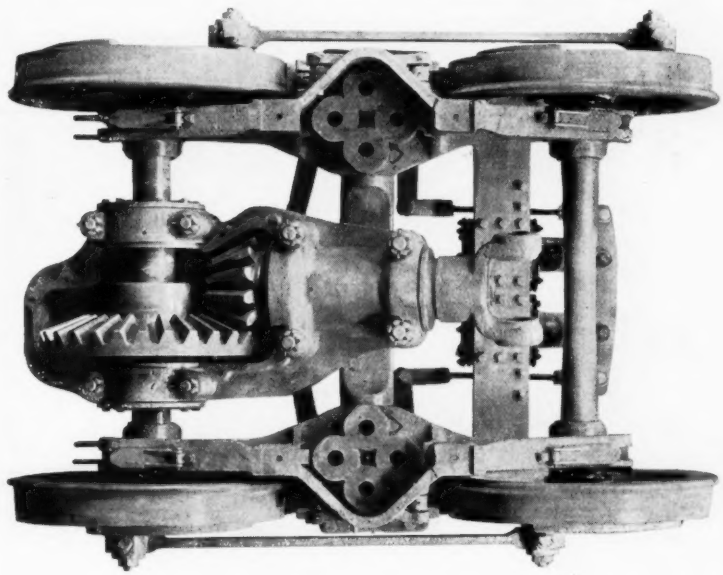
Layout of transmission, double-bogie diesel-electric locomotive

of battery charge with manual cut-out. All the equipment with the exception of the controller, starting and control switches, and meters, are housed in ventilated cabinets, and the reverse and throttle levers are interlocked to safeguard the components.

The bogies are bar-framed, each in the form of a single casting, and carry the weight at the sides through two four-coil nests of helical springs, the bolsters being steel castings with tapered roller side bearings. The bevel wheels are forced on the axles before the rail wheels are pressed on, and they are completely encased by oil-tight cast steel covers, the top half of which is shown off in the last of the accompanying illustrations. A one-piece Commonwealth steel casting forms the underframe, the side members varying in depth from 12 to 16 in. On this bed the cab and engine compartment structure is built up. The cab being centrally situated, the locomotive may be operated in either direction without the driver moving his position, and to facilitate shunting work further, the controls are duplicated, one set being provided at each side of the cab. Westinghouse brakes apply blocks to the inside of all wheels, the two compressors, with a combined capacity of 118 cub. ft. per minute, being driven off the main engine-generator coupling through the medium of belts. A handbrake is also fitted to hold the locomotive when out of service. Timken roller bearings have been applied to the truck side bearers, and are understood to have given good performance over a period of intensive switching service. The trucks themselves are based on the design of those of the standard Heisler geared steam locomotive. Other equipment includes air sanding gear operated by a foot pedal; pneuphonic horn and air operated bell; M.C.B. couplers, and a Madison-Kipp ten-feed mechanical lubricator for the transmission components.

The principal dimensions and particulars of this heavy slow-speed shunting locomotive are as follows: b.h.p., 360; weight in working order, 53·5 tons; maximum rated tractive effort, 40,000 lb.; hourly tractive effort at 3·8 m.p.h., 22,500 lb.; maximum speed, 25 m.p.h.; wheel dia. 38 in.; bogie wheelbase, 5 ft. 1 in.; total wheelbase, 23 ft. 1 in.; length over coupler knuckles, 33 ft. 4 in.; total gear ratio, 8·26 : 1.

When tested with the New York Central Lines' dynamometer car and a string of big hopper cars, a maximum tractive effort of 47,800 lb. was recorded without slipping, and the locomotive generally showed itself to be the equal of an 85-ton steam engine in heavy slow-speed work. Further, the arrangement of the drive and coupling rods tends to make it superior to a normal Bo-Bo oil-electric locomotive, for one pair of wheels cannot slip by itself. In a direct competitive test on a 1 in 33 grade with a curve of 400 ft. radius, the Heisler locomotive hauled an 83 per cent. greater tonnage than could be hauled by a 71-ton superheated steam locomotive. In conducting the tests, the dynamometer car was located immediately behind the locomotive, and was followed by a number of double-bogie hopper cars. To the end of these was attached a steam shunting locomotive which was used to apply brakes to the train, and thus increase the load.



View looking down on Heisler truck

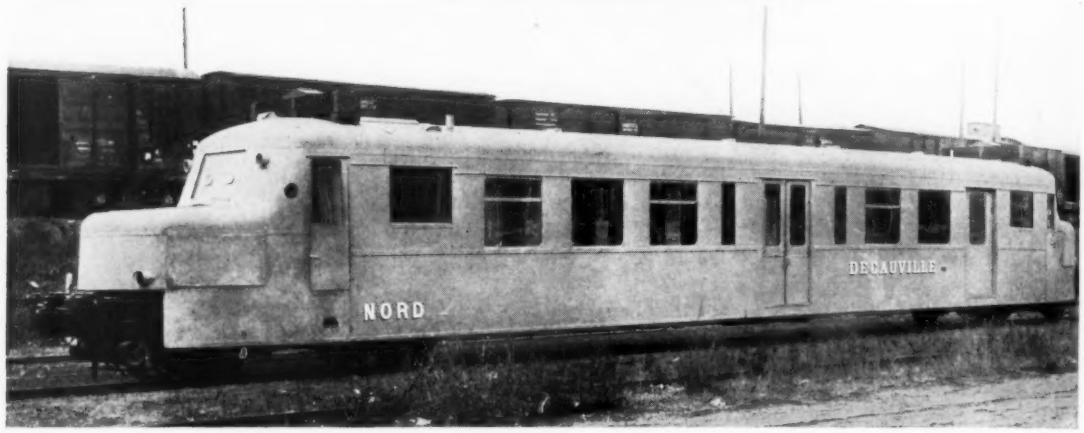
Mounting of Diesel Engines

Mr. P. C. Saccaggio, in his paper on experiences with diesel-electric traction read before the Institution of Mechanical Engineers in Buenos Aires last year, and which was abstracted in our issue for December 1 last, made some interesting remarks on the mounting of diesel engines in railway vehicles, and the effect which the different methods had on the riding qualities.

Although recognising that many engineers still require very substantial foundations in the form of built-up frames, Mr. Saccaggio considered that anything in the nature of a rigid connection between the wheels and the engine would have a deleterious effect upon the life. Every part of a diesel engine is subject to vibrations of various frequencies, which as a rule damp themselves out provided that the engine is not too rigidly held. The moment restriction of vibrations is introduced in the form of rigid frames, troubles occur, either in the engine itself, or in other parts of the structure. A rigid frame transmits to the diesel engine all the shocks that emanate from the rolling of the wheels over the track. These shocks may become very destructive by the gyroscopic effects produced on the gyrating engine shaft and its supports. The safest way out of the difficulty is to give the engine ample freedom by resting it on a common vehicle frame, supported on well-sprung bogies. On the mobile power houses of the Buenos Ayres Great Southern Railway, a person walking along the vehicle causes the body to move in unison with each footstep. These power houses ride very well at all speeds. The main-line diesel-electric locomotive was also built on the same principles of carriage, and at the high speed of 130 km.p.h. the riding was very steady. Furthermore, both types of vehicles took the curves with less oscillation than normal steam locomotives, and the author was convinced that all-bogie locomotives were best.

FIRST DIESEL CAR ON THE NORD

Light but powerful vehicle set to work on fast services



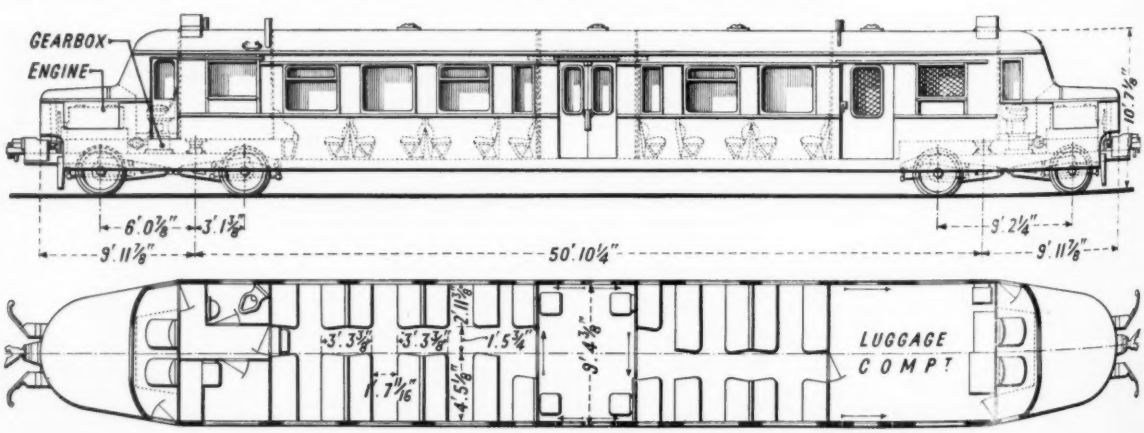
280 b.h.p. fast railcar, Ch. de fer du Nord

THE C. de f. du Nord is the last of the seven big French railways to adopt diesel traction, for the first oil-engined vehicle has just gone into service. As may be seen from the accompanying illustrations, it is of the double bogie type with a body of semi-streamlined contour with bonnets at each end housing the motive power units and radiators. The total engine power is sufficient to enable a trailer to be hauled.

Power is provided by two six-cylinder Saurer oil engines, each of which develops 140 b.h.p. at 1,500 r.p.m. The transmission is mechanical, and comprises for each engine an hydraulic clutch and an oil-operated four-speed gearbox of the Swiss Locomotive Company's type. Each engine-transmission combination is mounted direct on a bogie. The wheels have a diameter of 35½ in. and are fitted with standard tyres. Nickel-chrome steel has been used for the axles, which run in S.K.F. roller bearings. The bogie framework is of very rigid design and is constructed of chrome-molybdenum steel. Double spring suspension is used, and to assist a smooth action with some lateral stability, the bogie pivot is placed well behind the centre of the wheelbase. Lateral movement is controlled by swing links and a sliding pivot.

The body is of all-welded construction with the main members of chrome-nickel steel, and certain of the pillars and rails of duralumin. The external panels are of steel and duralumin, and those on the inside of almasilium. The floor of the vehicles consists of corrugated duralumin plates with cork strips in the undulations and an overlay of linoleum. Heating of the passenger compartment is effected by circulating the exhaust gases of the engines, and ventilation by Epervier-Gillet ventilators.

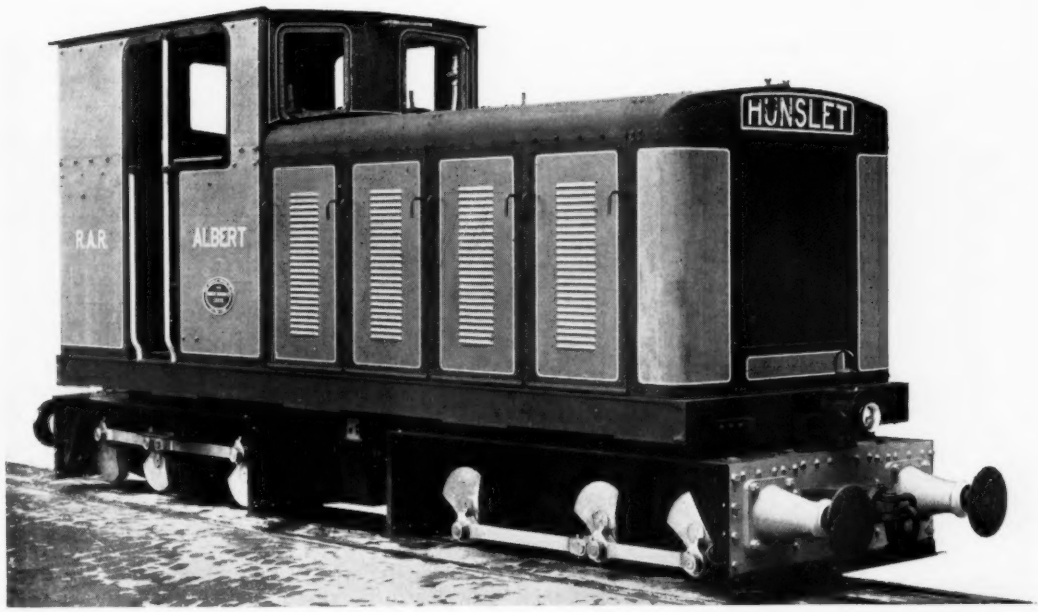
A driving cabin is fitted at each end of the car, and the driving controls are duplicated in both. Braking is effected by cam-operated blocks applied to drums inside the wheels by the Westinghouse automobile brake, and the air for this is also available for the sanding gear, which is fitted for both directions of running. Automatic centre couplers, light bumping irons, and railguards are fitted at each end of the vehicle.



Layout of Decauville double-engine diesel-mechanical railcar

LOCOMOTIVE FOR GOVERNMENT SERVICE

Woolwich Arsenal acquires 13-ton double-bogie shunting engine for use on narrow-gauge system



Diesel shunting locomotive with maximum tractive effort of 6,000 lb. for Woolwich Arsenal

A NEW type of motive power has recently been showing its paces on the extensive narrow-gauge railway network in Woolwich Arsenal, in the form of a diesel-mechanical locomotive built by the Hunslet Engine Co. Ltd. After satisfactory trials at the makers' works, the locomotive was put into regular operation at the beginning of this month on an 18-in. gauge line with curves as sharp as 30 ft. radius.

For such a narrow gauge, the engine output of 75 b.h.p. is not small, and should enable the locomotive easily to cope with the demands of the inter-shop and yard traffic. The engine is of the four-cylinder four-stroke McLaren type, and develops its rated power at 1,000 r.p.m., but is capable of a temporary increase to 82 b.h.p. at 1,100 r.p.m. C.A.V.-Bosch fuel injection equipment is provided, and the engine is started in the favourite Hunslet method, viz., by means of a small petrol engine, in this case a two-cylinder Scott engine which automatically engages and disengages with the main engine, and is itself started by hand from the cab. Accessibility of the power unit formed a basic consideration in the design, and by taking down loose shutters, which can easily be removed by one man, the engine, starting gear, and transmission are open for inspection, lubrication, and cleaning.

The drive from the engine to the gearbox is taken through the Hunslet patent multi-plate friction clutch fitted with Ferodo bonded asbestos linings, and through a Hardy-Spicer flexible coupling, which is introduced to prevent any cross strains being set up in the frame by the movement of the bogies being transmitted to the main driving shaft. The Hunslet patent pre-selective change-gear mechanism is embodied, and although it is now being used with success on the second L.M.S.R. diesel-mechanical locomotive by the same firm, this Government locomotive is by far the smallest application to date.

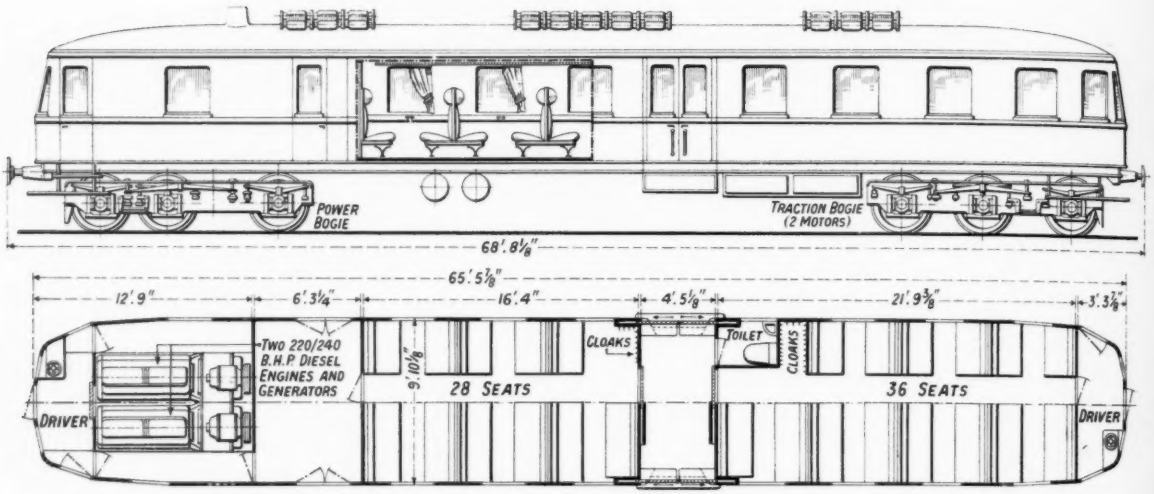
Mounted centrally in the main frames, the gearbox is of the constant-mesh type, with all shafts running in Ransomes & Marles roller bearings. A cardan shaft extends from each end of the gearbox to the adjacent bogie, and, in view of the sharply-curved line over which the locomotive has to work, special consideration was given to the flexible couplings, and the final choice rested on a spring type designed and manufactured by Standage Power Couplings Limited, which has so far given trouble-free operation, even when tested on curves of 30-ft. radius.

On the outer end of each bogie is fitted a transverse jackshaft which is driven from the cardan shaft through a central worm reduction gear. The drive is finally taken to the wheels through outside cranks and connecting rods; due to the small size and low axle loads of the locomotive, this layout was preferred to a directly-driven worm on the axle, as it reduces the unsprung wheel load by half the weight of the worm, worm wheel, and gear case. Further advantages are that the worm gear case can be arranged as a bogie frame stretcher with such a narrow gauge, and that the cardan shafts have to accommodate only curving movement.

All wheels are braked by the Westinghouse straight air brake, the air for which is supplied by a two-cylinder compressor driven from the main engine. A hand brake is also incorporated, and is worked in conjunction with the air brake. It is compensated to operate equally on both bogies. Air sanding gear for operation in both directions is fitted, and the cab is provided with doors, sliding shutters, and heating pipes. The wheels are 18-in. diameter, the bogie wheelbase 3 ft., and the total wheelbase 12 ft.

EXPRESS DIESEL RAILCARS

The first of ten twelve-wheeled, double-bogie vehicles has just been set to work on the Danish State Railways



Layout of Frichs high-speed railcar, Danish State Railways

THE Danish State Railways some time ago placed an order with A/S Frichs for ten high-speed diesel-electric railcars each with two six-wheel bogies. The first of these cars, which were illustrated and described in the *Diesel Railway Traction Supplement* for July 14, and for December 29, 1933, has now been delivered, and during its trials has shown remarkable results. The power plant, which consists of two 240 b.h.p. engines mounted directly on one of the bogies, was briefly described in the issue of this Supplement for July 14 last.

The body is fabricated of steel plates, and the ends are slightly rounded, although not actually streamlined. There are two passenger saloons with a total seating accommodation of 64, and the car is entered through double sliding doors placed in the centre. The seats have arm and head rests, as may be seen from one of the accompanying illustrations, and they are covered in leather. The interior panelling is of birch, with mahogany pillars. In a corner of each compartment there is a rack for hats and coats, and between the passenger saloon and engine room is a commodious luggage room.

Designed for fast passenger work, the cars have a maximum designed speed of 75 m.p.h., but on test a speed of 84 m.p.h. was reached. Over a level road they can accelerate from rest to 60 m.p.h. in 100 sec., and on the first trial run one of them started from Aarhus station and accelerated up a six-mile gradient of 1 in 100 to a speed of 60 m.p.h. at the top. During some experimental runs on the Copenhagen-Korsor division, where the new triple-articulated diesel trains are to begin running next year, one of these 480 b.h.p. vehicles covered the 68½ miles in 65 min. The cars are being put into traffic on various routes, and all will be in regular operation by May. They are capable of hauling a load of 80 tons on normal schedules, in addition to their own fully-laden weight of 59 tons. One of them, with trailer, is to run from Copenhagen to Kalundborg before an express train, and will pick up passengers from all stations.

480 b.h.p. diesel-electric express railcar

Interior of passenger compartment